What is claimed is:

1. A projection optical system capable of forming an image of an object, comprising, objectwise to imagewise, along an optical axis:

a) a first lens group having positive refractive power;

b) a second lens group having negative refractive power;

c) a third lens group having positive refractive power;

d) a fourth lens group having negative refractive power and a first aspherical surface;

e) a fifth lens group having positive refractive power and an aperture stop;

f) wherein the projection optical system is designed such that paraxial rays traveling parallel to the optical axis imagewise to objectwise intersect the optical axis at a location Q between said fourth lens group and said fifth lens group;

g) at least one of said fourth and fifth lens groups includes a second aspherical surface arranged between said first aspherical and said aperture stop;

h) said fifth lens group includes a third aspherical surface arranged imagewise of said aperture stop; and

i) wherein the following condition is satisfied:

$$0.01 < d_Q/\{L \times (1 - NA)\} < 0.4 \qquad (1)$$

wherein the image and the object are separated by a distance L, said location Q and said aperture stop are separated by a distance d_Q, and NA is an imagewise numerical aperture of the projection optical system.

2. A projection optical system according to claim 1, wherein said aperture stop has a variable size and is located imagewise of said location Q such that vignetting is minimized when said variable size is changed.

3. A projection optical system according to claim 1, wherein:

a) said first aspherical surface is concave and includes refractive power at a paraxial region and refractive power at a periphery, wherein said refractive power at said periphery is weaker than said refractive power at said paraxial region;

b) said second aspherical surface includes refractive power at a paraxial region and refractive power at a periphery, and is one of:

  i) a convex surface, with said refractive power at said periphery weaker than said refractive power at said paraxial region; and

  ii) a concave surface, with said refractive power at said periphery stronger than said refractive power at said paraxial region; and

c) said third aspherical surface includes refractive power at a paraxial region, and refractive power at a periphery, and is one of:

  i) a convex surface, with said refractive power at said periphery weaker than said refractive power at said paraxial region; and

  ii) a concave surface, with said refractive power at said periphery stronger than said refractive power at said paraxial region.

4. A projection optical system according to claim 1, wherein said first lens group has at least one aspherical surface.

5. A projection optical system according to claim 1, wherein said second lens group has at least one aspherical surface.

6. A projection optical system according to claim 1, wherein said third lens group has at least one aspherical surface.

7. A projection optical system according to claim 1, satisfying the following conditions:

$$0.05 < f1/L < 0.5 \qquad (2)$$

$$0.02 < -f2/L < 0.2 \qquad (3)$$

$$0.04 < f3/L < 0.4 \quad (4)$$

$$0.03 < -f4/L < 0.3 \quad (5)$$

$$0.04 < f5/L < 0.4 \quad (6)$$

wherein f1 through f5 are focal lengths of said first through fifth lens groups, respectively.

8. A projection optical system capable of forming an image of an object, comprising, objectwise to imagewise, along an optical axis:

a) a first lens group having positive refractive power;

b) a second lens group having negative refractive power;

c) a third lens group having positive refractive power;

d) a fourth lens group having negative refractive power and a first aspherical concave surface with refractive power at a paraxial region and refractive power at a periphery, wherein said refractive power at said periphery is weaker than said refractive power at said paraxial region;

e) a second aspherical surface arranged imagewise of said first aspherical surface and having refractive power at a paraxial region and refractive power at a periphery, and being one of:

  i) a convex surface, with said refractive power at said periphery weaker than said refractive power at said paraxial region; and

  ii) a concave surface, with said refractive power at said periphery stronger than said refractive power at paraxial region;

f) a fifth lens group having positive refractive power, an aperture stop, and a third aspherical surface arranged imagewise of said aperture stop, wherein said third aspherical surface includes a paraxial region, a periphery and refractive power and is one of:

  i) a convex surface, with said refractive power at said periphery weaker than said refractive power at said paraxial region; and

  ii) a concave surface, with said refractive power at said periphery stronger than said refractive power at paraxial region; and

g) wherein the projection optical system is designed such that paraxial rays traveling parallel to the optical axis imagewise to objectwise intersect the optical axis at a location Q between said fourth lens group and said fifth lens group.

9. A projection optical system according to claim 8, wherein said first lens group has at least one aspherical surface.

10. A projection optical system according to claim 8, wherein said second lens group has at least one aspherical surface.

11. A projection optical system according to claim 8, wherein said third lens group has a least one aspherical surface.

12. A projection optical system according to claim 8, satisfying the following conditions:

$$0.05 < f1/L < 0.5 \qquad (2)$$
$$0.02 < -f2/L < 0.2 \qquad (3)$$
$$0.04 < f3/L < 0.4 \qquad (4)$$
$$0.03 < -f4/L < 0.3 \qquad (5)$$
$$0.04 < f5/L < 0.4 \qquad (6)$$

wherein f1 through f5 are focal lengths of said first through fifth lens groups, respectively.

13. An exposure apparatus for imaging a pattern present on a reticle onto a photosensitive workpiece, comprising:

a) a first stage for supporting the reticle;

b) an illumination optical system adjacent said first stage for illuminating the reticle;

c) a second stage for supporting a workpiece; and

d) a projection optical system arranged between said first stage and said second stage, said projection optical system comprising in order from said first to said second stage:

i) a first lens group having positive refractive power;

ii) a second lens group having negative refractive power;

iii) a third lens group having positive refractive power;

iv) a fourth lens group having negative refractive power and a first aspherical surface;

v) a fifth lens group having positive refractive power and an aperture stop;

vi) wherein the projection optical system is designed such that paraxial rays traveling parallel to the optical axis imagewise to objectwise intersect the optical axis at a location Q between said fourth lens group and said fifth lens group;

vii) wherein at least one of said fourth and fifth lens groups includes a second aspherical surface arranged between said first aspherical surface in said fourth lens group and said aperture stop;

viii) wherein said fifth lens group includes a third aspherical surface arranged imagewise of said aperture stop; and

ix) wherein the following condition is satisfied:

$$0.01 < d_Q/\{L \times (1 - NA)\} < 0.4 \qquad (1)$$

wherein said image and said object are separated by a distance L, said position Q and said aperture stop are separated by a distance d_Q, and NA is an imagewise numerical aperture of the projection optical system.

14. An exposure apparatus according to claim 13, wherein said reticle stage and said workpiece stage are moveable along a scanning direction, and said projection optical system includes an exposure field having a first dimension orthogonal to said

scanning direction and a second dimension along said scanning direction, wherein said first dimension is greater than said second dimension.

15. An exposure apparatus according to claim 14, wherein said first dimension is at least 25 mm.

16. A method of patterning a photosensitive workpiece with a pattern present on a reticle, the method comprising the steps of:

a) illuminating the reticle;

b) projecting light from said reticle with the projection optical system as set forth in claim 1; and

c) exposing said photosensitive workpiece over an exposure field.

17. A device manufacturing method comprising the steps of:

a) coating a photosensitive material onto a substrate;

b) projecting onto said substrate the image of a pattern of reticle through the projection optical system set forth in claim 1; and

c) developing said photosensitive material on said substrate, thereby forming a photoresist pattern.

18. A method according to claim 17, further comprising the step, after said step c), of forming a pattern in said substrate based on said photoresist pattern.

19. A projection optical system capable of forming an image of an object, comprising, objectwise to imagewise along an optical axis:

a) a first lens group having positive refractive power and a plurality of lenses including a negative lens;

b) a second lens group having negative refractive power and a plurality of negative lenses;

c) a third lens group having positive refractive power and a plurality of positive lenses;

d) a fourth lens group having negative refractive power;

e) a fifth lens group having positive refractive power and a plurality of lenses including a negative lens; and

f) an imagewise maximum numerical aperture NA_{MAX} of at least 0.8.

20. A projection optical system according to claim 19, further including an aperture stop located in said fifth lens group.

21. A projection optical system according to claim 20, further satisfying the following condition:

$$0.01 < d_Q/\{L \times (1 - NA)\} < 0.4 \qquad (1)$$

wherein said image and said object are separated by a distance L, Q is a position located a distance d_Q from said aperture stop wherein paraxial rays traveling parallel to the optical axis imagewise to objectwise intersect the optical axis, and wherein NA is an imagewise numerical aperture of the projection optical system.

22. A projection optical system according to claim 20, further including an exposure field having a dimension of at least 25 mm.

23. A projection optical system according to claim 20, wherein the number of lenses objectwise of said aperture stop is at least six, and the number of lenses imagewise of said aperture stop is at least four.

24. A projection optical system according to claim 20, wherein said aperture stop has a variable size such that the projection optical system has a numerical aperture NA satisfying the relation:

$$0.6 \times NA_{MAX} \le NA \le NA_{MAX} .$$

25. A projection optical system according to claim 20, wherein the optical axis is unfolded.

26. A projection optical system having specifications and characteristics as set forth in Tables 1A-1C.

27. A projection optical system having specifications and characteristics as set forth in Tables 2A-2C.

28. A projection optical system having specifications and characteristics as set forth in Tables 3A-3C.

29. A projection optical system having specifications and characteristics as set forth in Tables 4A-4C.

30. A projection optical system according to claim 8, satisfying the following conditions:

$$0.05 < f1/L < 0.5 \qquad (2)$$

$$0.02 < -f2/L < 0.2 \qquad (3)$$

$$0.04 < f3/L < 0.4 \qquad (4)$$

$$0.03 < -f4/L < 0.3 \qquad (5)$$

$$0.04 < f5/L < 0.4 \qquad (6)$$

wherein f1 through f5 are focal lengths of said first through fifth lens groups, respectively.

31. A method of patterning a photosensitive workpiece over an exposure field with a pattern present on a reticle, the method comprising the steps of:

a) illuminating the reticle with light;

b) projecting the light from the reticle with the projection optical system as set forth in claim 8; and

c) exposing the photosensitive workpiece over the exposure field.

32. A projection optical system according to claim 1, wherein:

(a) said first aspherical surface is concave and includes refractive power at a paraxial region and refractive power at a periphery, wherein said refractive power at said periphery is weaker than said refractive power at said paraxial region;

(b) said second aspherical surface including refractive power at a paraxial region, and refractive power at a periphery, wherein said refractive power at said periphery is more negative than said refractive power at said paraxial region; and

(c) said third aspherical surface including refractive power at a paraxial region, and refractive power at a periphery, wherein said refractive power at said periphery is more negative than said refractive power at paraxial region.

a/o A3 Cont.

33. An exposure apparatus for imaging a pattern present on a reticle onto a photosensitive workpiece, comprising:

(a) a first stage for supporting the reticle;

(b) an illumination optical system adjacent said first stage for illuminating the reticle;

(c) a second stage for supporting the workpiece; and

(d) a projection optical system arranged between said first stage and said second stage, said projection optical system comprising in order from said first to said second stage:

(i) first lens group having positive refractive power;

(ii) a second lens group having negative refractive power;

(iii) a third lens group having positive refractive power;

(iv) a fourth lens group having negative refractive power and a first aspherical concave surface with a paraxial region, a periphery and refractive power, wherein said refractive power at said periphery is weaker than said refractive power at said paraxial region;

(v) a second aspherical surface arranged imagewise of said first aspherical surface and having a paraxial region, a periphery and refractive power, said first aspherical surface being one of:

(1) a convex surface, with said refractive power at said periphery weaker than said refractive power at said paraxial region; and

(2) a concave surface, with said refractive power at said periphery stronger than said refractive power at said paraxial region;

(vi) a fifth lens group having positive refractive power, an aperture stop, and a third aspherical surface with a paraxial region, a periphery and refractive power, said third aspherical surface being one of:

(1) a convex surface, with said refractive power at said periphery weaker than said refractive power at said paraxial region; and

(2) a concave surface, with said refractive power at said periphery stronger than said refractive power at said paraxial region; and

(vii) wherein the projection optical system is designed such that paraxial rays traveling parallel to the optical axis imagewise to objectwise intersect the optical axis at a location Q between said fourth lens group and said fifth lens group.

34. An exposure apparatus according to claim 33, wherein said first stage and said second stage are movable along a scanning direction, and said projection optical system includes an exposure field having a first dimension orthogonal to said scanning direction, and a second dimension along said scanning direction, wherein said first dimension is greater than second dimension.

35. An exposure apparatus for projecting a image of a pattern present on a reticle onto a photosensitive workpiece, comprising:

(a) a first stage designed so as to be movable along a scanning direction and to support the reticle;

(b) an illuminating optical system adjacent said first stage arranged so as to illuminating the reticle with light;

(c) a second stage designed so as to be movable along at least said scanning direction, for supporting the photosensitive workpiece;

(d) a projection optical system, arranged between said first stage and said second stage, having a plurality of lenses and an aperture stop, said plurality of lenses and said aperture stop designed such that said light from said reticle is capable of being guided to an exposure field on said substrate with an imagewise maximum numerical aperture of at least 0.8; and

(e) wherein said exposure field has a first dimension orthogonal to said scanning direction, and a second dimension along said scanning direction, wherein said first dimension is greater than said second dimension, and wherein said first dimension is at least 15mm.

36. A exposure apparatus according to claim 35, wherein said exposure field has a slit shape, with said first dimension of said slit shape being at least 25mm.

37. A exposure apparatus according to claim 34, wherein at least one of said plurality of lenses includes an aspherical surface.

Sub A4

38. A method of pattering a photosensitive workpiece with a pattern present on a reticle, the method comprising the steps of:

(a) illuminating the reticle with light from said illuminating optical system of said exposure apparatus of claim 35;

(b) projecting the light from the reticle with the projection optical system of said exposure apparatus of claim 35; and

(c) exposing said photosensitive workpiece over said exposure field.

add B1

add C3